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DOCUMENT 751-93

JOINT RANGE INSTRUMENTATION
ACCURACY IMPROVEMENT GROUP

SATELLITE CALIBRATION REQUIREMENTS

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WHITE SANDS MISSILE RANGE
KWAJALEIN MISSILE RANGE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ELECTRONIC PROVING GROUND

ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
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April 1993

Satellite Calibration Requirements

Joint Range Instrumentation Accuracy Improvement Group
Range Commanders Council
White Sands Missile Range, NM 88002-5110

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This document specifies user requirements for instrumentation onboard any future calibration satellites.

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NONE

SATELLITE CALIBRATION REQUIREMENTS

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1.0 INTRODUCTION

One of the tasks brought before the Joint Range Instrumentation Accuracy Improvement Group (JRIAIG) was to create a Satellite Calibration Requirements document (task JR-2). This document specifies user requirements for instrumentation onboard any future calibration satellites. The listed satellite user requirements will not necessarily be levied on the satellite; however, these requirements will be considered should funding and equipment or space and weight become available.

Six ranges responded to the request for specifications to be incorporated into the Satellite Calibration Requirements document. Five of the replies included specifications for a C-band transponder, which indicates that this is the area of greatest concern among the test ranges. Requirements specifications were also received for S-band and X-band transponders, and for telemetry (TM), and Global Positioning System (GPS) capabilities. Table 1 indicates the categories of specifications received from each range.

TABLE 1. SATELLITE CALIBRATION REQUIREMENTS RESPONSES					
RANGE SITE	C-BAND	S-BAND	X-BAND	TM	GPS
1. Air Force Flight Test Center Edwards AFB, CA	X		X	X	X
2. STEEP-ET-U U.S. Army Electronic Proving Ground Fort Huachuca, AZ	X				
3. STEYP-MT U.S. Army Yuma Proving Ground Yuma, AZ	X				
4. WTR/PE 30th Space Wing Vandenberg AFB, CA	X	X			X
5. U.S. Army Kwajalein Atoll Kwajalein Missile Range	X				
6. STEWS-ID White Sands Missile Range, NM		X			

2.0 USER REQUIREMENTS

In this section, the user requirement responses are compiled in separate tables for each of the five categories of desired capability: C-Band, S-Band, X-Band, Telemetry, and GPS.

2.1 C-BAND TRANSPONDER

The required C-band transponder characteristics were specified in varying forms by each of the five ranges responding to this part of the task. However, the only incompatible specifications are for the non-coherent transponder frequency.

In all other areas, characteristics can be specified which satisfy the requirements of all five ranges. For example, all ranges specified a two-pulse beacon with 2.5 microsecond delay, while pulse repetition frequency (PRF) specifications varied widely but without being mutually exclusive. Where possible, these varying specifications have been combined into one requirement that satisfies each of the submitted requirements. A compilation of the various transponder requirements is given in table 2, along with an indication of which ranges specified each of these characteristics.

TABLE 2. C-BAND TRANSPONDER CHARACTERISTICS					
TRANSPONDER CHARACTERISTICS	AFBTC	EPG	YPG	30 SPW	USAKA
1. ACCURATE DELAY AND PULSEWIDTH MEASUREMENTS REQUIRED				X	
2. BEACON CODE: 2 PULSES, 8 MICROSECONDS SPACING	X	X	X	X	X
3. BEACON DELAY: 2.5 +/- 0.01 MICROSECONDS	X	X	X	X	X
4. DYNAMIC RANGE: 0 TO 85 DBM				X	
5. MINIMUM TRANSMITTER PEAK POWER: 100 WATTS	X	X	X	X	X
6. PHASE COHERENCE REQUIRED				X	
7. POLARIZATION OMNI DIRECTED CIRCULAR				X	
8. PRF CAPABILITY: 320 AND 640 PPS			X		
9. PRF CAPABILITY: 1200 PPS (MINIMUM)	X	X			X
10. PRF CAPABILITY: 1600 PPS (MINIMUM)				X	
11. RECEIVER SENSITIVITY: -60 DBMW	X	X			X
12. RECEIVER SENSITIVITY: -70 DBMW			X		
13. REPLY PULSEWIDTH: 0.5 TO 1.0 MICROSECONDS	X	X	X	X	X
14. RISE TIME: 0 TO 0.1 MICROSECONDS				X	
15. TRANSPONDER FREQUENCY: NON-COHERENT 5690 MHZ RECEIVER	X	X			X
16. TRANSPONDER FREQUENCY: NON-COHERENT 5765 MHZ TRANSMITTER	X	X			X
17. TRANSPONDER FREQUENCY: COHERENT 5765 MHZ	X			X	X
18. TRANSPONDER FREQUENCY: NON-COHERENT 5585 MHZ RECEIVER			X		
19. TRANSPONDER FREQUENCY: NON-COHERENT 5700 MHZ TRANSMITTER			X		

2.2 S-BAND TRANSPONDER

Two ranges indicated a need for a satellite-borne S-band transponder. One of these ranges specified an unmodulated transmitter with a frequency of 2250 MHz and 100 watts minimum power. The other range suggested no specific characteristics. These responses are summarized in table 3.

TABLE 3. S-BAND TRANSPONDER CHARACTERISTICS	
RANGE SITE	TRANSPONDER CHARACTERISTICS
30 SPW	1. S-Band required for calibration satellite
WSMR	1. Transmitter Frequency: 2250 MHz 2. Transmitter Modulation: Unmodulated 3. Minimum Transmitter Power: 100 Watts

2.3 X-BAND TRANSPONDER

Only one of the responding ranges specified requirements for an X-band transponder. Table 4 is a list of the desired transponder characteristics for X-band, which indicate a single-pulse beacon with approximately 1.0 microsecond delay operating in the lower half of the X-band spectrum. Receiver sensitivity and transmitter power requirements are also specified, as well as desired pulsewidth and PRF.

TABLE 4. X-BAND TRANSPONDER CHARACTERISTICS	
RANGE SITE	TRANSPONDER CHARACTERISTICS
AFFTC	1. Beacon Code: Single Pulse 2. Beacon Delay: 1.0 +/- 1.0 Microseconds 3. Minimum Transmitter Peak Power: 300 Watts 4. PRF Capability: 2800 pps 5. Receiver Sensitivity: -65 dBW 6. Reply Pulsewidth: 0.3 +/- 0.1 Microseconds 7. Transponder Frequency: Non-Coherent (Preferred) 8.5 - 9.5 GHz

2.4 TELEMETRY

The AFFTC was the only range to provide telemetry specifications. Desired L-band and S-band telemetry frequencies are shown in table 5, along with required receiver sensitivity and transmitter power specifications.

TABLE 5. TELEMETRY CHARACTERISTICS	
RANGE SITE	CHARACTERISTICS
AFFTC	<ol style="list-style-type: none"> 1. L-Band: 1435 - 1849 MHz 2. S-Band: 2200 - 2400 MHz 3. Minimum Transmitter Peak Power: 20 Watts 4. Receiver Sensitivity: -108 dBmW

2.5 GPS RECEIVER

Requirements for a GPS receiver were specified by two ranges. The AFFTC-specified features include a receiver capable of handling Selective Availability/Anti-Spoofing (SA/A-S) and high dynamics and able to collect pseudo-range measurements from 12 satellites at 10 Hz while measuring delta range by means of continuous carrier phase tracking. Table 6 lists these desired features, along with specific data items required for off-board processing. A statement of required accuracy for 30th Space Wing (30 SPW), Vandenberg AFB, California is also included.

TABLE 6. GPS RECEIVER FEATURES	
RANGE SITE	RECEIVER FEATURES
AFFTC	<ol style="list-style-type: none"> 1. SA/A-S and high dynamics capable receiver. 2. Able to simultaneously track L1 and L2 signals from 12 GPS satellites. 3. Capable of making pseudo-range and delta range measurements at 10 HZ rate. Delta range measurements should be made continuously (that is, continuous carrier phase tracking). 4. Data output from receiver should include <ol style="list-style-type: none"> a. all pseudo-range and delta range measurements, b. "user-time" of measurements, c. measurement validity indicators, d. trajectory estimate (ephemeris data) calculated from the GPS measurements, and e. GPS satellite navigation message subframes 1, 2, and 3 data.
30 SPW	<ol style="list-style-type: none"> 1. GPS translator or receiver to provide real time location with 5-meter accuracy.

3.0 CONCLUSION

The satellite calibration requirements presented in this document are simply a compilation of the responses to the request for input into this JRIAIG task. This document is intended as a guide to aid the appropriate JRIAIG working group in the task of drafting requirements that fulfill the satellite calibration needs of all interested test ranges.